LBNE Beam Alignment Studies

3/3/10

Mary Bishai (BNL)

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Motivation

The alignment of the neutrino beamline at FNAL with the FD is a critical component of civil constructions

- **The NuMI beamline was required to be aligned to 0.1mradians**
- **What is the requirement for LBNE that satisfies the physics?**

The LBNE beam

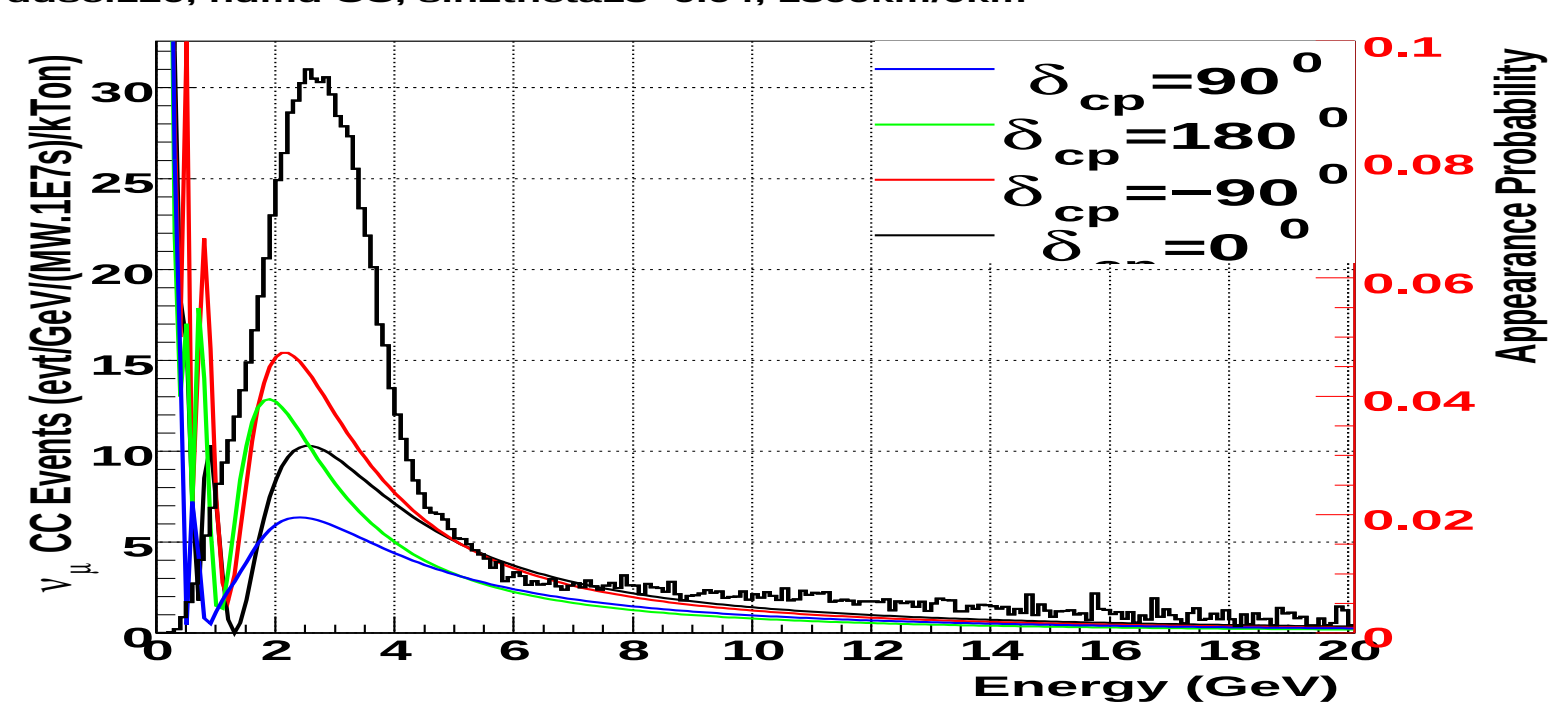
Simulation details (NOT FINAL DESIGN!):

Beam: 120GeV, $\sigma = 1.5$ cm

Target: Cylindrical, carbon, 6mm radius, 80cm length, 2.1g/cm^3

Horns: 2 AI NuMI horns, 6m apart, 250kA current both.

Decay pipe: Cylindrical, vacuum, 2m radius, 280m length.



Kinematics of neutrino production

For $\theta_\nu < 1$

$$E_\nu = \frac{0.43 E_\pi}{1 + \gamma_\pi^2 \theta^2}$$

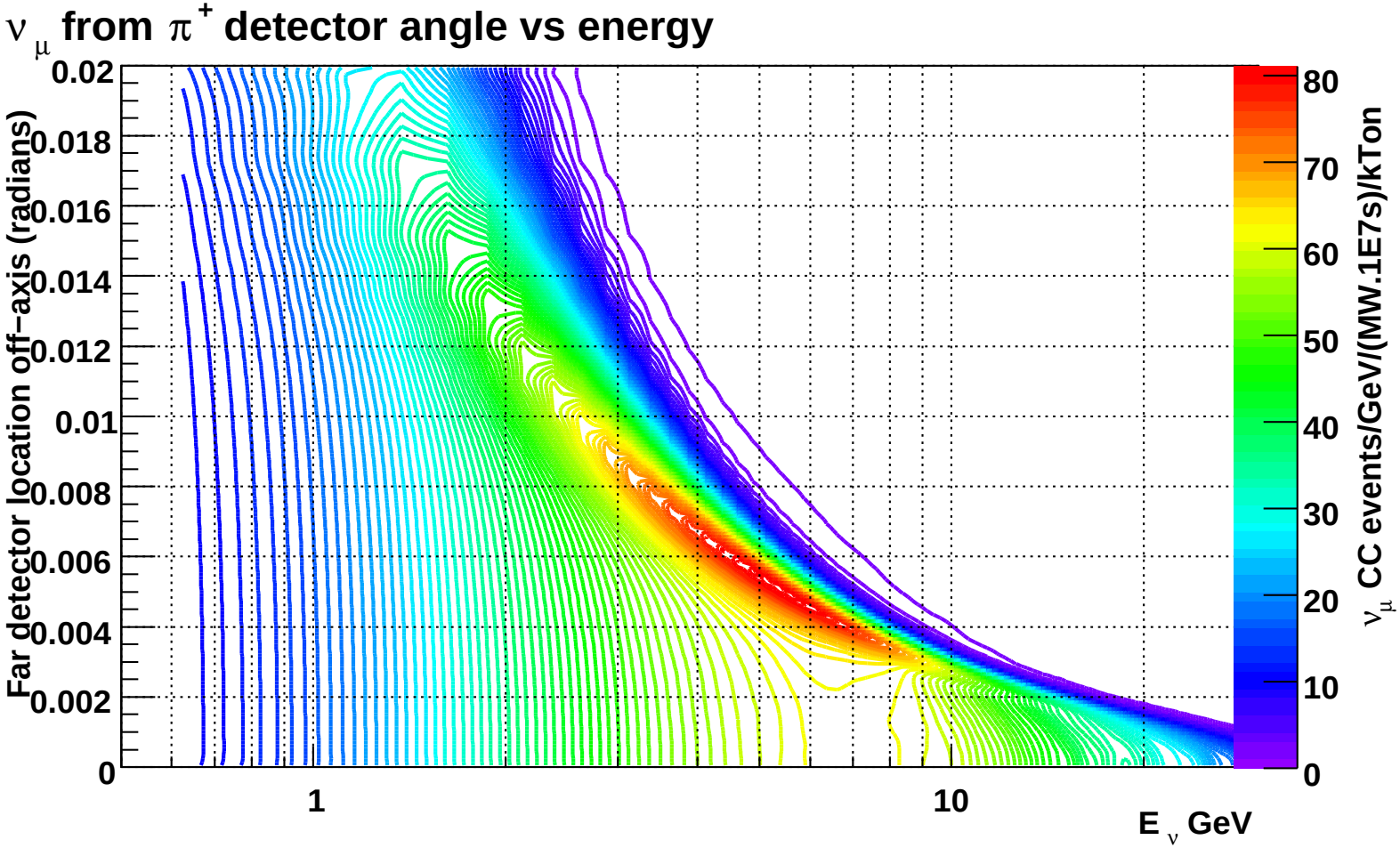
$$\frac{dN}{d\Omega} \sim \frac{1}{\pi}\left(\frac{\gamma^2}{1 + \gamma_\pi^2 \theta^2}\right)$$

For example

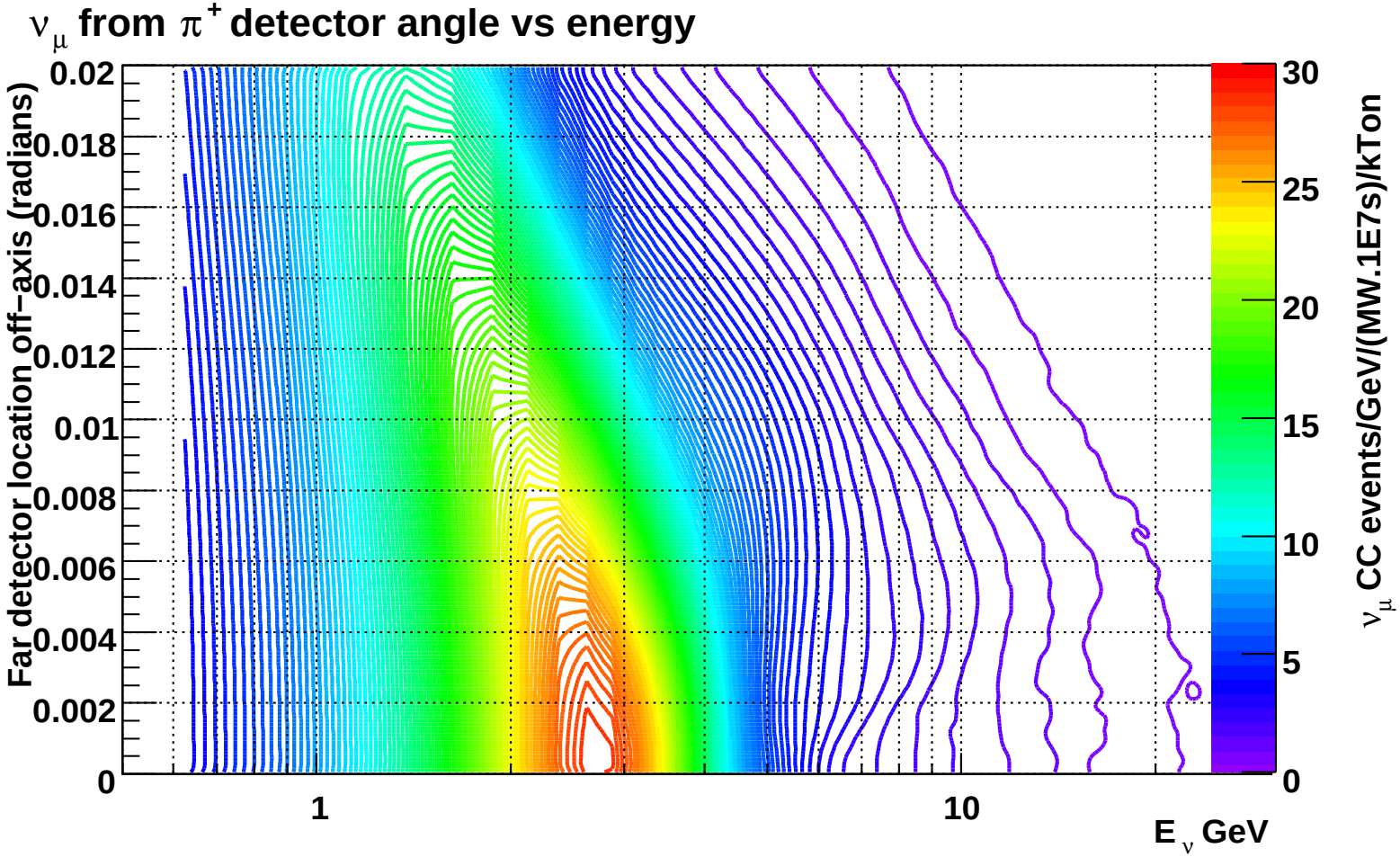
E_{pi} (GeV)	θ_ν mrads	E_ν GeV
6.0	0	2.580
6.0	1	2.575
6.0	10	2.180
14	0	6.02
14	1	5.96
14	10	3.01

In the region $E_\nu < 6$GeV, E_ν differences are $< 1\%$ up to 1mrad off-axis

Going off-axis - perfect focusing



Going off-axis - real focusing

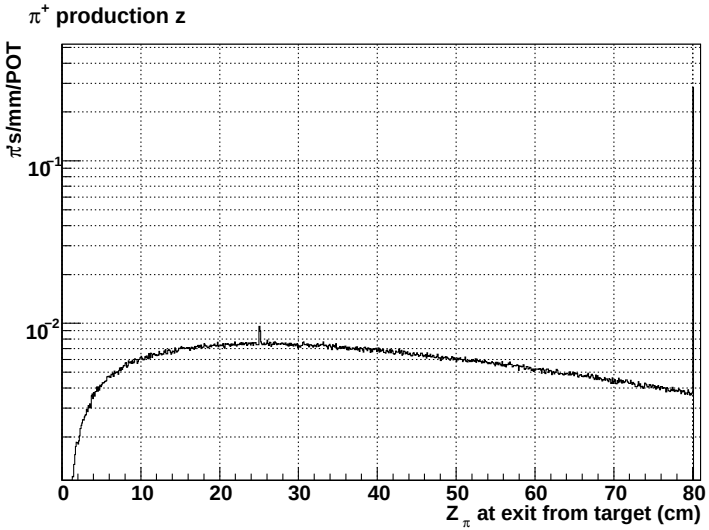


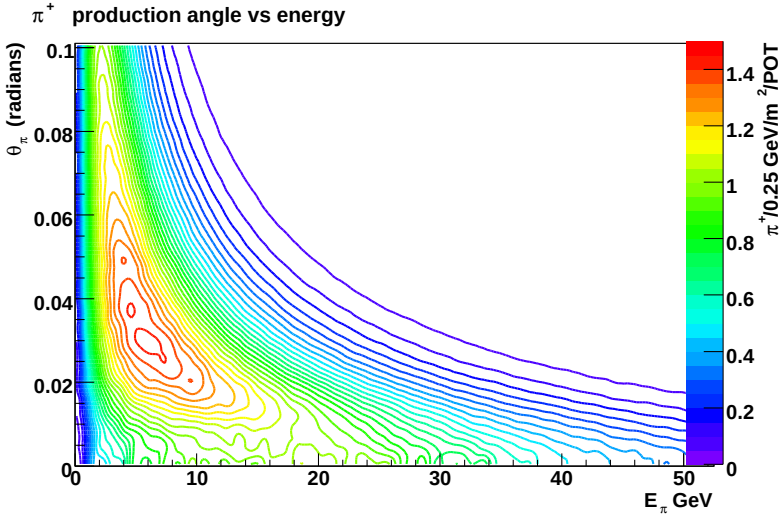
High energy rates DO NOT decrease as expected off-axis

Pion beam divergance and focusing

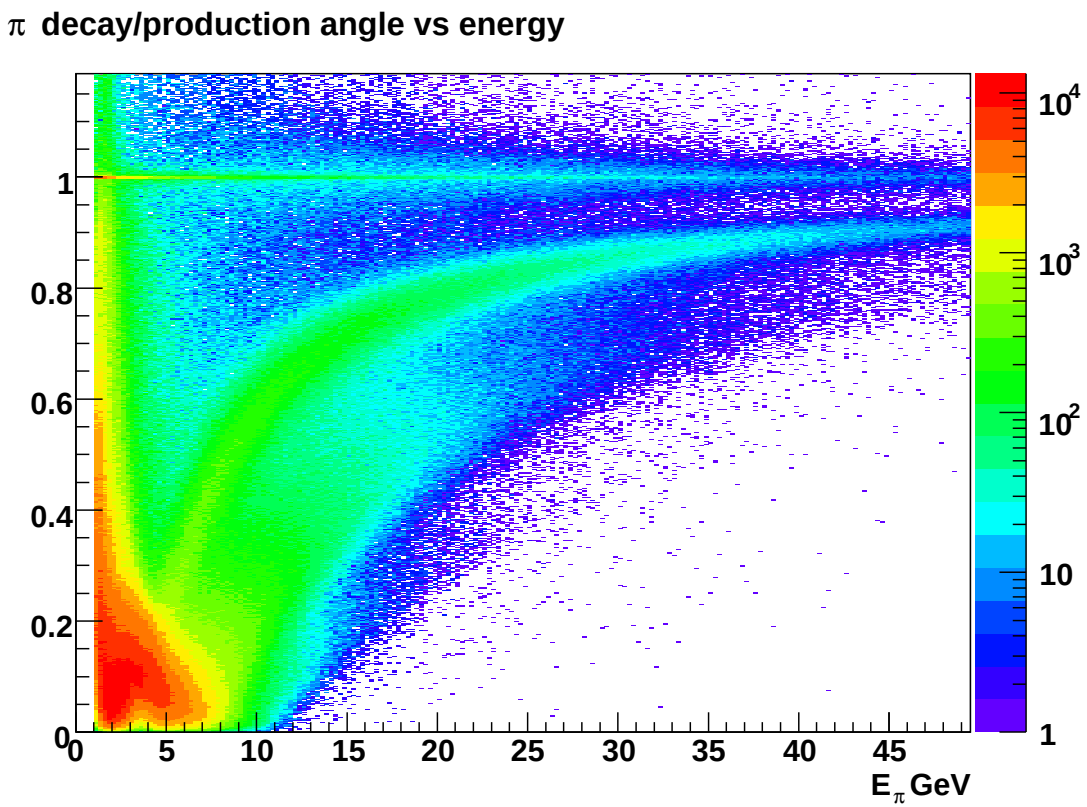
90% of the pions produced from the target are emitted through the sides $\Rightarrow$ there is a "natural" divergance to the pion beam from the target shape. $\theta_\pi > 6\text{mm}/70\text{cm} = 9\text{mrad}$.

From the FLUKA08 simulation:





Focusing efficiency



Focusing not as efficient for high energy pions

$\Rightarrow$ high energy pions peak slightly off-axis

Off-axis spectra ν_μ, ν_e

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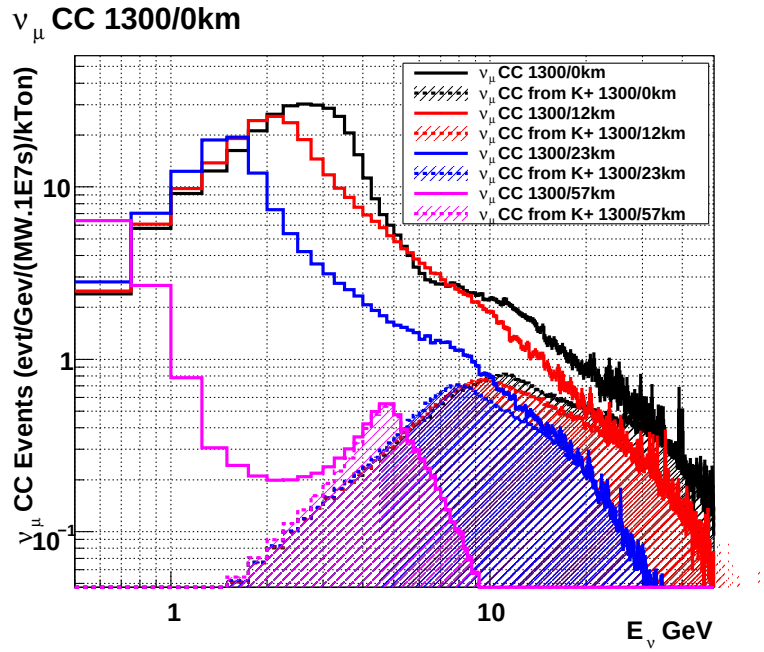

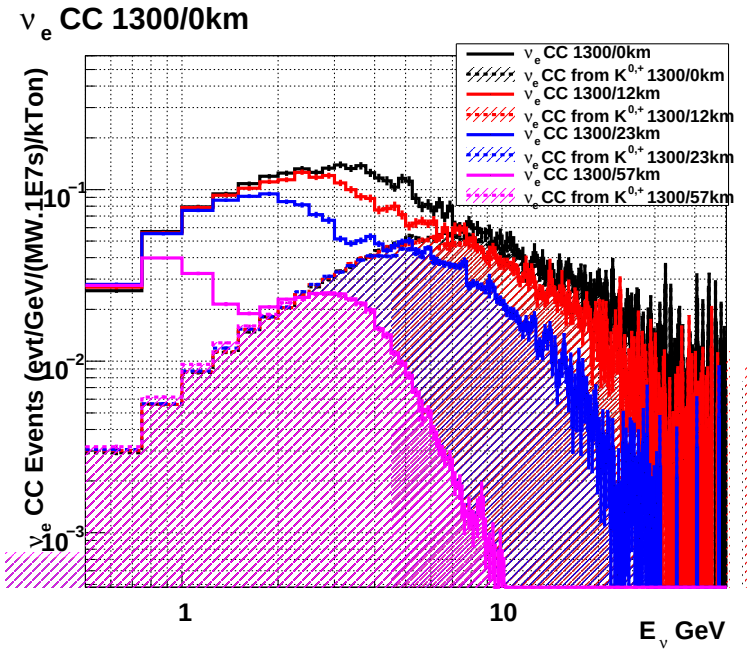

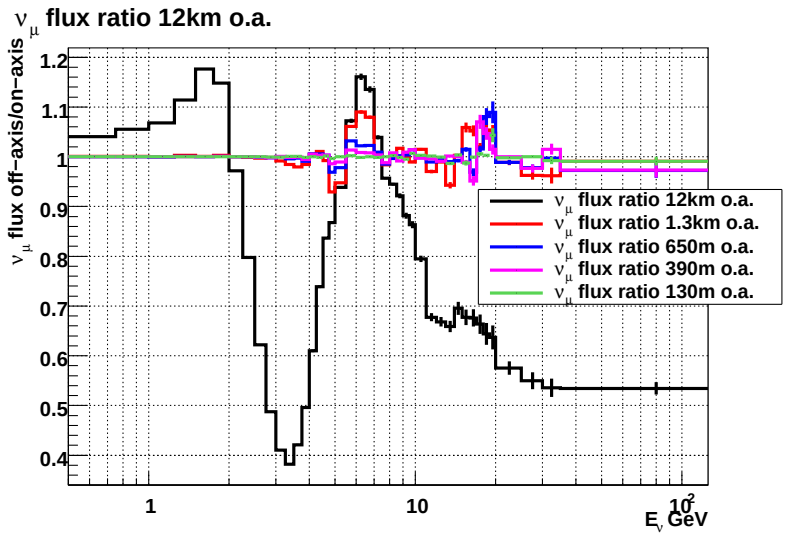

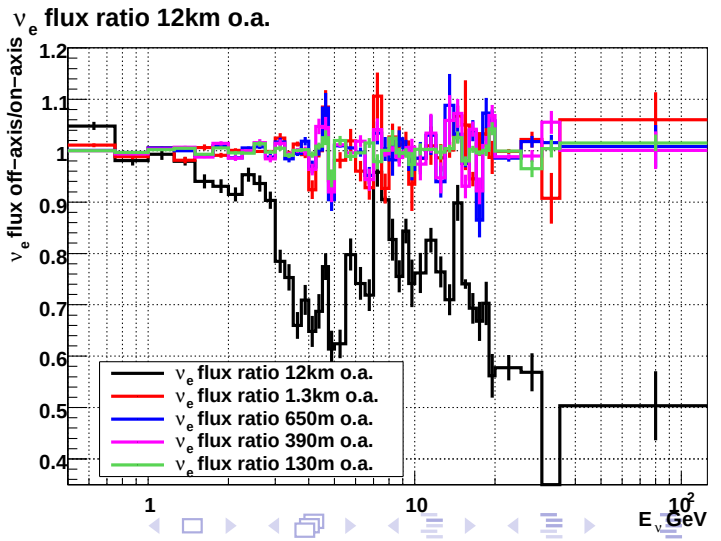

Discussion points

- **At 1mrad offaxis, 10 % change in E_ν around 6 and 20 GeV. This is $<$ 2-3 % change in NC contamination in ν_e appearance analysis.**
- **Can we reduce the divergance of the pion beam off-axis by changing the target shape?**
- **Can we use the high energy tunes with the FD to FIT FOR THE off-axis beam and thereby eliminate need for physical alignment to better than 1mrad?**